Chapter 8.1

Coastal Bays Ecosystem Health Index: Bringing it all together

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Abstract
Estuarine health indicators comprised of water quality, living resources and habitat features were used to compare the different bay segments within the Maryland Coastal Bays. The selected estuarine health indicators are responsive to human activities and were measured throughout the Maryland Coastal Bays. Overall bay health ranked Sinepuxent best followed closely by Chincoteague Bay and St. Martin River worst. Assawoman, Isle of Wight and Newport bays were all ranked similarly in a fair to poor status. Continued nutrient reduction and habitat preservation/restoration are needed in all subwatersheds except Sinepuxent.

Introduction
The preceding chapters described the environmental status and trends of the many ecosystem indicators monitored in the Maryland Coastal Bays to provide a tracking point for how the bays are faring. While many of these indicators showed improvements throughout the bays, such as water quality, others had definitive downward trends, such as seagrass acreage. Furthermore, status and trends in several ecosystem elements varied, sometimes widely, between bay segments. Likewise, if tributaries and the open water bays are separated and compared, marked differences in indicator values, especially water quality, become apparent.

The purpose of this document is to provide a comprehensive assessment of ecosystem health for use in driving policy decisions. The information on the status of the various indicators contained in each chapter are important individually, especially to stakeholders interested in one or a few indicators, those who are responsible for making decisions affecting the ecosystem often request more comprehensive answers. To this end, an estuarine health index was developed based on the results of this report and a summary of overall ecosystem health.

Estuarine health indicators comprised of water quality, living resources, and habitat features were used to compare the different bay segments within the Maryland Coastal Bays. The selected estuarine health indicators are responsive to human activities and were measured throughout the Maryland Coastal Bays. Two water quality indicators (water quality index and macroalgae), two living resources indicators (benthic index and hard clam abundance), and two habitat indicators (seagrass area and wetland area) were used to rank the estuarine health in each embayment. Though the index covers a wide variety of indicators used in the preceding report, its coverage is not exhaustive. For instance, no stream or fisheries indicators were used to create the index. Furthermore, all of the indicators used were weighted equally in the analysis.

Analysis

For each of the six indicators listed above, average values over each of the Coastal Bays segments were calculated. Each indicator was scored based on the data in the preceding report as follows:

Water quality index

The water quality index was a within-segment average of the water quality index values calculated for each Coastal Bays fixed station. This index was calculated from three-year median values for total nitrogen and phosphorus, chlorophyll *a* concentration, and dissolved oxygen concentration. Please see Chapter 4.4 for a detailed explanation of how the water quality index was calculated as well as values for each station.

Macroalgae

Maximum total macroalgal biomass per square meter (g/m^2) within each segment over the period 1999 through 2013 was used. While raw macroalgal biomass was not reported in this document, the values used for this indicator were the same as those used to develop Figure 5.4.1 (see Chapter 5.4).

Benthic index

The within-segment mean Mid-Atlantic Integrated Assessment (MAIA) benthic index score (2010) was used (see Chapter 7.4).

Hard clams

The average of the number of clams per station within each segment for 2013 was used (see Chapter 7.3, especially Figure 7.3.2).

Seagrass area

The total seagrass acreage within each segment was used, based on the 2013 survey data (see Chapter 5.1). These values were then converted to a percentage of goal attainment for that subwatershed.

Wetland area

Raw within-segment National Wetland Inventory acreages from the 1988 through 1989 survey were used. These values were then converted to a percentage of the total watershed land acreage. Since Isle of Wight Bay and the St. Martin River were considered one segment for this analysis, the scaled value for the combination was used for each in the final analysis.

Results

Within-segment means served as raw index values for each segment (Table 8.1.1). Raw values were converted to scaled values by setting the lowest score among the segments to zero and the highest to one. Those scores falling between zero (worst) and one (best) were scaled accordingly (Table 8.1.2). The set of scaled values was then averaged within segment, resulting in a final estuarine health index value for each segment (Table 8.1.2).

Table 8.1.1 Raw values for each indicator by segment. Indicators are divided into water quality (blue), living resources (yellow), and habitat (green) categories.

Indicator / Segment	WQI[1]	Macroalgae[2]	Benthic index[3]	Hard clams[4]	Seagrass area[5]	Wetland area[6]
Assawoman Bay	0.33	718.3	3.25	0.28	35.14	45
Isle of Wight Bay	0.44	545.2	2.88	0.73	22.6	44
St. Martin River	0.11	134.1	1.83	0.06	3.96	44
Sinepuxent Bay	0.70	49.6	5	0.33	62.06	61
Newport Bay	0.34	99.2	2.25	0.1	16.75	25
Chincoteague Bay	0.56	74.8	3.89	0.18	45.62	62

[1]Water quality index ranges from 0 (no reference criteria met) to 1 (all reference criteria met). [2]Grams/m^2. [3]Ranges from 1(poor) to 5(good). [4]Clams/m^2. [5]Percent of segment goal met. [6]Percent of watershed.

Table 8.1.2 Scaled values for each indicator by segment, based on raw values in Table 8.1.1 (zero values are the worst ranking and one is the best condition). Final index values are also shown. Indicators are divided into water quality (blue), living resources (yellow), and habitat (green) categories.

Indicator / Segment	WQI[1]	Macroalgae	Benthic index	Hard clams	Seagrass area	Wetland area	**Estuarine Health Index**
Assawoman Bay	0.4	0.0	0.4	0.3	0.5	0.6	**0.4**
Isle of Wight Bay	0.6	0.3	0.3	1.0	0.3	0.0	**0.4**
St. Martin River	0.0	0.9	0.0	0.0	0.0	0.0	**0.1**
Sinepuxent Bay	1.0	1.0	1.0	0.4	1.0	1.0	**0.9**
Newport Bay	0.4	0.9	0.1	0.1	0.2	0.2	**0.3**
Chincoteague Bay	0.8	1.0	0.6	0.2	0.7	0.6	**0.7**

[1]Water quality index.

Discussion

Final rankings, based on average scaled values, were, from best to worst: Sinepuxent Bay, Chincoteague Bay, Assawoman Bay/ Isle of Wight Bay, Newport Bay and St. Martin River (Table 8.1.3). These segment rankings are all relevant to each other; that is, no reference estuaries were used to base ranking. Generally, the pattern of rankings reflects those predicted by most of the indicators used in the preceding document, with tributary dominated subwatershed demonstrating lower indices than open bay segments and southern bays scoring better than northern bays. These indices, based on raw values, are summarized in Table 8.1.3, which should be referenced throughout the rest of this discussion.

Sinepuxent Bay had the highest ranking of 0.9 because it scored the highest or near the highest for all indicators. This highest ranking reflects this segment's small, relatively undeveloped watershed. Sinepuxent Bay is also well-flushed, due to its proximity to the Ocean City Inlet.

Chincoteague Bay ranked second, at 0.7, largely due to macroalgae. High seagrass area also contributed to the relative health of this largest segment of the Coastal Bays. Like Sinepuxent Bay, Chincoteague Bay is relatively undeveloped, due to its proximity to the protected Assateague Island National Seashore, but has a much larger watershed.

Assawoman and Isle of Wight segments tied for third both with a rank of 0.4. Assawoman Bay had a low water quality index (identical to Newport Bay), due to high nutrient and chlorophyll *a* levels, as well as very low seagrass area drove this ranking. Grey's and Roy's creeks, and the ditch connecting Assawoman Bay to Little Assawoman Bay in Delaware contributed the most to the low water quality index value. Assawoman Bay was saved from a lower ranking due mainly to mid-range habitat indicators (wetlands and seagrass coverage).

Isle of Wight Bay demonstrated the highest hard clam densities and reasonable water quality, but low values in both habitat indicators. Despite being downstream of heavily eutrophic St. Martin River and containing several nutrient-impacted waterways (Turville, Herring, and Manklin Creeks), water quality was mid-range for this segment. This could be due to flushing from the Ocean City Inlet. Next to the St. Martin River, Isle of Wight Bay has the most developed watershed in the Coastal Bays. This heavy development has been implicated in the low values of habitat indicators.

Newport Bay ranked fifth among the Coastal Bays' segments due to poor water quality, low living resources and low habitat indicators. Newport Bay suffers from chronically high phytoplankton concentrations (as evidenced by chlorophyll *a* values) reduced hard clam densities, and very little seagrass coverage. Newport Bay is somewhat sheltered, and thus not well flushed. Another contributor to these poor indicator values may be increasing development in the upper reaches of the watershed (second most populated subwatershed).

Ranking last, the St. Martin River had the lowest index values for all indicators except macroalgae. This river had the highest phytoplankton and phosphorus concentrations, as well as the lowest dissolved oxygen concentrations (see breakout in Table 8.1.3). All three living resources indicators ranked the lowest in this river, and seagrass and wetlands were nearly non-existent. A combination of poor flushing and heavy nutrient loading from both agriculture and development probably contribute to the decline of the St. Martin River.

Overall, this break-down of the Coastal Bays into segments and the development of this index provides a thumbnail sketch of how the Coastal Bays fare ecologically. The northern bays are doing worse, in general, than the southern bays. Such an index provides a concise report that is easily accessible by stakeholders and interested citizens alike. Those responsible for managing the resources in a certain segment or the bays as a whole will hopefully find this useful, as will citizens living in the individual watersheds. This index also provides a means to summarize a comprehensive report that is based on reams of data and associated analyses.

However, this approach has its drawbacks. First, not all of the data contained in the full report lent itself to use in the index. As a result, some potentially informative indicators were left out altogether. For example, the coastal bays fishery program data was not set up to give information at the sub-watershed scale but to determine overall stock changes.. This is partially to do with the fact that the index was developed *a posteriori*, but since the entire report is a compilation of many different studies and long term monitoring programs this was unavoidable.

Furthermore, certain indicators had to be dropped compared to previous assessments (Dennison et al 2009 and Carruthers et al 2004) due to no updated data for sediment toxicity, shorelines, or wetlands. To keep a balanced approach between the three categories (water quality, habitat and living resources) one indicator was dropped from each category (brown Tide, sediment toxicity and shorelines). Updating the date for each of the missing data sets or determining new indicators in the categories would be beneficial to the overall ecological health assessment.

References

Dennison, W.C., J.E. Thomas, C.J. Cain, T.J.B Carruthers, M.R. Hall, R.V. Jesien, C.W. Wazniak and D.E. Wilson. 2009. Shifting Sands: Environmental and cultural changes in Maryland's Coastal Bays. University of Maryland Center for Environmental Science.

Carruthers, T.J.B, C.E Wazniak, W.C. Dennison and M.R. Hall. 2004. Coastal Bays Ecosystem Health Index: Bringing it all together. Chapter 9.1 In: Maryland's Coastal bays: Ecosytem Health Assessment 2004.

Table 8.1.3 Estuarine health index results,

2011–2013 ESTUARINE HEALTH INDEX		Sinepuxent Bay	Chincoteague Bay	Isle of Wight Bay	Assawoman Bay	Newport Bay	St Martin River
WATER QUALITY	Water quality index	10.0	7.6	5.6	3.7	3.9	0.0
	Macroalgae	10.0	9.6	2.6	0.0	9.3	8.7
LIVING RESOURCES	Benthic index	10.0	6.5	3.3	4.5	1.3	0.0
	Hard clams	4.0	2.0	10.0	3.0	1.0	0.0
HABITAT	Seagrass area	10.0	7.2	3.2	5.4	2.2	0.0
	Wetland area	10.0	6.4	0.0	6.4	1.6	0.0
ESTUARINE HEALTH INDEX		**9.0**	**6.6**	**4.1**	**3.8**	**3.2**	**1.5**

This table shows the 2011–2013 Estuarine Health Index for each of the Coastal Bays. Each indicator is scored from 0–10, based on how close it is to achieving the goal for that indicator, where a score of 0 = 0% attainment and a score of 10 = 100% attainment.